International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249–6890; ISSN (E): 2249–8001
Vol. 9, Issue 5, Oct 2019, 433–444

THERMAL PERFORMANCE ENHANCEMENT OF CYLINDRICAL HEAT PIPE USING TiO_2 NANOFLUID

BOGGULA SHARUK[1], P. LAKSHMI REDDY[2] & E. SIVA REDDY[3]

[1]Department of Mechanical Engineering, G. Pulla Reddy Engineering College, Kurnool, Andhra Pradesh, India

[2,3]Assistant Professor, Department of Mechanical Engineering, G. Pulla Reddy Engineering College, Kurnool, Andhra Pradesh, India

Original Article

ABSTRACT

Heat pipe has been used as one of the alternative methods to absorb more heat in the cooling systems of electronic devices. An experimental study of heat transfer execution of heat pipe for examining the effect of different layers screen mesh wick and Titanium Oxide (TiO_2) nano fluid as operating fluid was conducted. Three heat pipes were fabricated. In this heat pipes, with multilayer of screen mesh wick are used to improve capillary activity of working liquid. Heat pipes having 12.5 mm diameter and 300 mm total length are selected. The heat pipes are tested with water and TiO_2 as working fluid for different heat inputs i.e. 50 W, 100 W, 150 W, and 200 W. In this work, considered base fluid as De-ionized water and adding different concentrations of Titanium Oxide (TiO_2) for minimizing the thermal resistance and increasing the thermal conductivity of a screen mesh wick heat pipe. Heat pipe material was copper (Cu), mesh material also copper, and testing heat pipe was done with different concentrations of nanofluid.

***KEYWORDS:** Heat Pipe, Titanium Oxide, Screen Mesh Wick, De-ionized Water, Thermal Resistance, Thermal Conductivity & Copper*

Received: Jun 14, 2019; **Accepted:** Jul 04, 2019; **Published:** Sep 17, 2019; **Paper Id.:** IJMPERDOCT201938

1. INTRODUCTION

Heat channels and their applications in heat administration have been considered for quite a long time. They comprise a productive conservative device to disseminate considerable measure of heat from different designing frameworks, including gadgets cooling like PCs, PC journals etc.[1]. The heat pipe has been generally utilized for cooling high power thickness gadgets because of its high successful conductivity, great heat spreading ability and geometric adaptability. The heat pipe is an exceedingly viable latent gadget for transmitting heat at high rates over extensive separations with very little temperature drops, excellent adaptability, basic development and simple control with no outside siphoning power [2].

The heat move capacity of the all heat move gadgets including heat pipe is restricted by the working liquid vehicle properties. To defeat these restrictions, the thermo physical properties of the working liquid must be improved [3]. The heat move rate of heat move gadgets can be improved by adding added substances to the working liquids to change the liquid vehicle properties and stream highlights. The presentation of heat channels is affected by numerous parameters, for example, the power, the sort, porosity and penetrability of the wick, the sort and measure of working liquid and the geometry of the heat pipe researched the impacts of the quantity of screen work layers and liquid stacking on the screen work wick heat pipes[4].

The nanofluid involved nano particles with an estimation of 17 nm and DI water. The full scale heat check of the warmth pipe using nanofluids was differentiated and that of the warmth pipe using DI water. Exploratory results exhibited that the outright warmth impediment of the warmth pipe using nanofluids was diminished by about 40%, differentiated and that using DI water at different filling extents [5]. In increasingly complex slender structures, for example, networks or sintered powder, it is hard to compute the precise area of both the fluid and the vapour inside the framework and furthermore hard to decide it tentatively. Hypothetical model depend on Darcy's law, with the penetrability and the identical heat conductivity of the slim structure as primary parameters. Tentatively, temperature estimations are utilized to appraise the most extreme power and the general heat resistance [6].

The heat pipe is grown particularly for space applications during the mid-60' by the NASA. One principle issue in space applications was to move the temperature from within to the outside, in light of the fact that the heat conduction in a vacuum is exceptionally restricted [7]. The thought behind is to make a stream field which transports heat vitality starting with one spot then onto the next by methods for convection, on the grounds that convective heat move is a lot quicker than heat move because of conduction. The heat introduction of a treacherous heat channels is regularly depicted by the two its most noteworthy heat transport rate and its fruitful heat block [8].

From this time forward, there has been noteworthy research revolved around developing better models to foresee the weight drop that occurs in naughty heat channels. There has been recharged enthusiasm for the utilization of heat channels for heat administration because of expanding heat motion prerequisites and heat limitations in numerous mechanical applications [9]. The heat pipe has predominantly three associated areas: evaporator, adiabatic segment and condenser. The significant segments of a heat pipe are a fixed holder, a wick structure, and a working liquid. The working liquid must have great heat solidness properties at the predefined operational temperature and weight. The quality and sort of wick for the most part decides the exhibition of the heat pipe, for this is the core of the item. Various kinds of wicks are utilized relying upon the application for which the heat pipe being utilized.

2. PREPARATION OF NANO FLUID

Figure 1: Probe Sonicator.

Figure 2: Preparation of Nanofluid.

The mixture of nanoparticles and a base fluid is known as a nanofluid. A pivotal to get heat properties improvement is to give an anticipated and strong nanofluid. A few materials might be used to see nanoparticles for unequivocal applications, which can be dispersed into fluids. Nano fluids are created as a mix of nanoparticles of metals, oxides, nitrides, metal carbides, and other non-metals, with or without surfactant particles, and water, ethylene glycol or oils. Two frameworks are used to pass on nanofluid. First, is the single-step direct dispersing way of thinking, which simultaneously makes and spreads the nanoparticles clearly into the base fluids, and the other is the two-advance system, which first makes nanoparticles and after that dissipates them into the base fluids. Nano fluids can lose their ability to move heat, since they are slanted to blend.

In the present assessments ultrasonic vibration, by a probe sonicator was used for dispersing and disaggregating the particles. Appraisals were done starting from a mix of half in mass, for instance 20% in volume, of titanium oxide (TiO_2) dissipated in water which was checked from Alfa Aesar. A surfactant was accessible at a concentration under 1%. The nanofluid was debilitated using bi-refined water, to get the other volume parts (0.05%, 0.15%, and 0.25%) by techniques for an exactness consistency KERN 440-45 N. The medium size of particles was round with a separation transversely over around 40 nm as certificated by the creator. The dispersing of the particles was gotten by first mixing the required volume of mix in a fair cup to refined water for getting the desiderated obsession and after that using ultrasonic vibration, by a probe sonicator, in order to scatter it. Particle by and large estimations after mix course of action and sonication were around 120 nm for all obsessions as clear. The probe sonicator used was the '"Hielscher UP 400S" (frequency = 24 kHz).

The standard thickness of titanium is proportionate to 3940 kg/m^3 and that of water is undefined from 998.2 kg/m^3. A couple of models were taken at common between times, by finding the gathering of heat conductivity as a bit of the season of sonication. Tests were taken at different districts of the sonicated shower. It was found that during the sonication, heat conductivity regards are from the begin by and large factor, while assessed conductivity watches out for an anticipated worth. Unequivocally when that happens, further walks around sonication don't smart essential changes in the conductivity of the nanofluid, making it possible to suspend the way of thinking examining consistency of the property.

3. EXPERIMENTAL SETUP

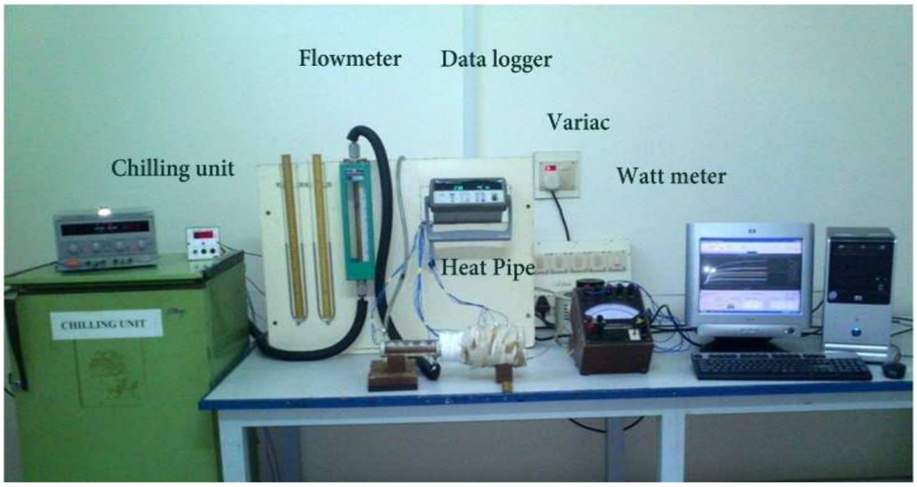

Figure 3: View of Heat Pipe Setup.

The exploratory arrangement, mostly comprises of heating coil, Digital Ammeter and Voltmeter to give the vital capacity to the Heating loop. The temperatures of the heat pipe estimated by utilizing a computerized temperature pointer with five thermocouples at various areas. The Digital temperature pointer is utilized to record the thermocouple readings at various purposes of the heat pipe. In absolute five thermocouples joined on the heat pipe divider, for example two at both the evaporator and condenser segment, and one at the adiabatic area. The thermocouples are welded over the outside of the heat pipe. The whole heat pipe is protected by utilizing protecting material to maintain a strategic distance from heat misfortune from the framework. A water coat, which comprises of delta and outlet ports for cooling water, is created. The temperature of cooling water at the channel and outlet are estimated utilizing thermocouples.

The examinations are performed with the heat pipe the even way. The heat commitment to the evaporator is extended in ventures of 50 W while the temperature of the coolant is kept up reliable at 18□. The temperature appropriated along the warmth pipe is assessed and recorded at the steady state condition. In light of the temperatures estimated. The exploratory arrangement comprises of an opposition radiator (greatest power yield of 1000 W), and a variable transformer to give required power by the heater. The information securing framework comprises of an information data logger (Agilent) and a PC framework for chronicle the information. T-type thermocouples are utilized to gauge the temperature reaction at various heat pipe areas. The inlet and outlet temperatures of the cooling water are moreover surveyed utilizing two T-type thermocouples. The thermocouple spots of warmth pipe endeavoured with DI water and nanofluids are shown in figure no.3. The thermo siphon heat pipe with anodized and non-anodized a copper tubes are tested at horizontal positions. Figure shows the estimation scheme and the thermocouple positions on the tested heat pipe.

The stream pace of the cooling water is evaluated when the glow pipe works relentlessly. The glow pipe with base liquids and nanofluids are sought after for the glow information moving from 100 W to 200 W. The adiabatic region, the power supply to the restriction radiator unit is turned on. The glow data is differentiated utilizing the variable transformer from 100 W to 200 W. Temperatures at various spots of the glow pipe and channel and outlet temperatures of the cooling water are checked by the data acquiring unit. The mass stream pace of cooling water at the condenser is assessed when the glow pipe works at suffering state.

The 50 watts of power passing in a heat pipe with help of the ammeter and voltmeter. The power is passed in a heat pipe then the temperature of the heat pipe is increased. All the temperatures of the heat pipe can be noted in a tabular column. The power can be increased in a 100 W, 150 W and 200 W. The power increased, then the heat transferred rate also increased and decreased in a thermal resistance. Tominimize the thermal resistance and increase the effective thermal conductivity of a screen, mesh wick heat pipe used.

4. RESULTS AND DISCUSSIONS

The temperature is recorded for the heat pipes using TiO_2/DI water nanofluids that are with concentrations of 0.05 vol. % and 0.25 vol. %. This concentration found to be less than those of the heat pipe with DI water. Even as reading the temperature of the heat pipe using 0.05 vol. % concentration of TiO_2/DI water nanofluid, it changed to be found that, as the heat load will increase from 50 W to better heat loads, the wall surface temperature and vapour core temperature were elevated at a higher rate, as compared to DI water heat pipe.

The amount of Nano powder required to prepare the nanofluid increases from 0.05 vol. % concentration to 0.25 vol. %. As the volume concentration will increase, because of the growth in quantity of Nano powder used for the practise,

the nanofluid will become extra viscous and in the end will increase its fluid density. This impacts the transport properties of the running fluid and creates a better drift resistance. Because of this reason, the performance of the heat pipe the use of 0.5 vol. % of TiO_2/DI water nanofluid heat pipe became inferior in comparison to DI water heat pipe. The main intension of the usage of nanofluids is to have a reduced surface temperature in comparison with conventional running fluids. For this reason, for further evaluation the nanofluids with 0.05 and 0.25 vol.% concentrations only were used, for the reason that they showed better performance.

As explained in advance, the wall surface temperature in the evaporator, adiabatic and condenser areas had been recorded for all of the three heat pipes for different warmth inputs. It is discovered that for the majority of the connected heat stacks the temperature conveyance of the heat pipe utilizing the two centralizations of nanofluid is low as contrasted and DI water warmth pipe. Out of the three heat pipes tested, the heat pipe with nanofluid having 0.05 vol. % concentration confirmed the lowest surface as well as vapour temperatures in all of the experiments.

The heat transfer functionality and the thermal performance of heat pipes depend upon the wall surface temperature distribution. Figures 4 give the distribution of wall surface temperature of the heat pipe along the axial duration starting from evaporator region, until the condenser region at various heat loads (100 W, 150 W and 200 W). In order to measure the temperature at evaporator, surface thermocouples had been used. The common evaporator surface temperatures were predicted.

The average evaporator surface temperature and adiabatic surface temperatures drop by 5.2% and 6.0% respectively, at 100 W heat loads for 0.05 vol. % TiO_2/DI water nanofluid. These temperatures drop have been 8.1% and 9.8% respectively for 0.25 vol. % TiO_2/DI water nanofluid heat pipes, as compared with DI water heat pipe. At 150 W heat load the reduction in temperature is 5.5%, 7.3% for 0.05 vol. % TiO_2/DI water nanofluid and 10.5%, 14.03% for 0.25 vol. % TiO_2/DI water nanofluid. Similarly a discount in temperature measurements of 13.8% and 13.0% for 0.05 vol. % TiO_2/DI water nanofluid and 18.5% and 16.9% for 0.25 vol. % TiO_2/DI water nanofluids were determined at 200 W heat loads, as compared to De-Ionized water heat pipe.

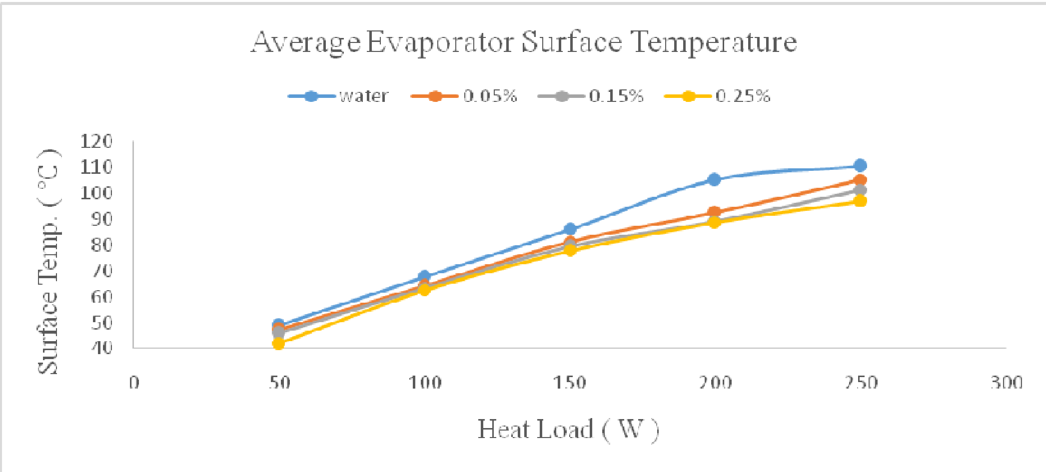

Figure 4: Average Evaporator Surface Temperature.

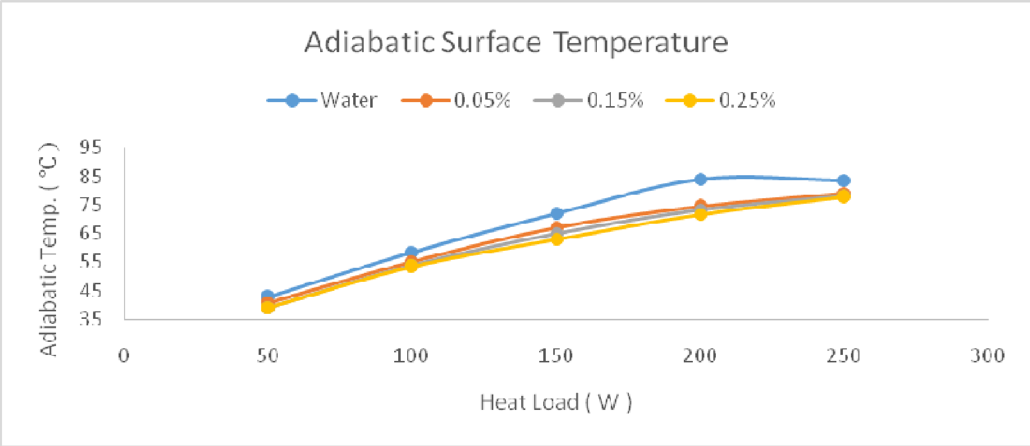

Figure 5: Adiabatic Surface Temperature.

Generally, five thermocouples have been used for the surface temperature size, two at evaporator regions one at adiabatic region and at condenser region. The average of five thermocouples suggests the average surface temperature. From Figure 4 a most drop of 13.83**%** in average surface temperature was received for 0.05 vol. % TiO_2/DI water nanofluid on the most power of 200 W, in which as in the case of 0.25 vol. % TiO_2/DI water nanofluid 18.59% decreased in surface temperature is acquired compared to De-Ionized water heat pipe. Those experiments correctly quantify the drop in evaporator and adiabatic temperatures and average surface temperatures under different load conditions.

Figure 4 offers a consolidation of comparison of average surface temperatures within the evaporator area, for different fluids. The giant drop in temperature is evident. The most of 18.02**%** drop is seen for the very best heat load considered within the gift observes for 0.05vol. % TiO_2/DI water nanofluid and 9.49**%** drop is located for 0.25vol. % TiO_2/DI water nanofluid. Whilst the TiO_2 nanoparticles had been dispersed with DI water, the temperature for the duration of the heat pipe surface also reduced substantially.

The studies of advanced researchers Hung et al. (2013), Do et al. (2010) etc. have shown that, addition of nanoparticles in base liquid, can increase the effective thermal conductivity of the base fluid. In all of the cases taken into consideration, the drop in temperature happened due to for different heat inputs. It is discovered that for the majority of the connected heat stacks the temperature conveyance of the heat pipe utilizing the two centralizations of nanofluid is low as contrasted and DI water heat pipe. But, the surface temperature distribution can also be related to the temperature distribution of the vapour. Figures 4 represents the distribution of temperature at vapour core of the heat pipes alongside the axial length from evaporator region to the condenser location, at various power (50 W, 100 W, 150 W and 200 W).

The evaporator common temperature of surface and adiabatic temperature of surface drops by way of 3.66% and 4.67% respectively, at a 50 W heat load for 0.05 vol. % De-Ionized water/TiO_2nanofluid and 7.12% and 9.08% respectively, for 0.25 vol. % TiO_2/DI water nanofluid compared with DI water. At 100 W heat load the discount in temperature is 5.2 % and 6.0% for 0.05vol. % TiO_2/DI water nanofluid and 8.12% and 9.80% for 0.25 vol. % TiO_2/DI water nanofluid. In addition a discount in temperature measuring 5.54% and 7.13% for 0.05 vol. % TiO_2/DI water nanofluid and 10.58% and a 14.05% for 0.25 vol. % TiO_2/DI water nanofluid is located at 150 W and subsequently a reduction in temperature measuring 13.83% and 13.00% for 0.05 vol. % TiO_2/DI water nanofluid and 18.59% and 16.92% for 0.25 vol. % TiO_2 /DI water nanofluid is found on the most heat load, 200 W in comparison to DI water heat pipe.

It is really located that the reduction in surface temperature is because of the excessive thermal conductivity of the TiO_2Nano powder, which displays inside the heat sporting capacity of TiO_2 nanofluid. But as the concentration of nanofluid will increase, its thermal performance decreases due to the growth in fluid density and its transport properties. This is why the performance of 0.05 vol. % TiO_2nanofluids is higher than that of 0.25 vol. % TiO_2 nanofluid. In Figure 5, variation of adiabatic surface temperature along the heat load is shown. Here, additionally in all the heat loads, the temperature is much less for 0.1 vol. % TiO_2 nanofluid.

The difference in wall surface temperature of evaporator region and condenser region in a heat pipe performs a considerable position in making sure its thermal overall performance. Lesser this quantity, the extra can be its heat delivery functionality. From figure 4 within the case of difference in wall surface temperature of evaporator and condenser, a discount of 11.98% is observed for 0.05 vol. % TiO_2 nanofluid heat pipe at 200 W. at the same heat load, a discount of 20.49% is found for 0.25 vol. % TiO_2 nanofluid heat pipe in comparison to DI water heat pipe. This again suggests that the heat pipe having 0.05 vol. % TiO_2 nanofluid as working fluid is more green in its thermal performance, equal trend changed into is found through Do et al. 2010.

Any other crucial performance parameter of heat pipe, which defines its overall performance under the given heat load situations is its thermal resistance, described in figure 4.3. As the power increases, then the thermal resistance reduces. The thermal resistance of all the three heat pipes under investigation is shown within the figure 6 It is found that, for the maximum heat load taken into consideration inside the study, in comparison with DI water heat pipe, a reduction of 24.4% is determined within the case of the heat pipe having 0.25 vol.% TiO_2 nanofluid. For the heat pipe having 0.05 vol.% TiO_2 nanofluid 9.37% reduction in thermal resistance is seen, which once more proved the wonderful thermal performance characteristics of 0.05 vol.% TiO_2/DI water nanofluid as working fluid inside the heat pipe application.

Figure 7 gives some other performance parameter of a heat pipe specifically, thermal conductivity that's described in equation. As per the work effective thermal conductivity is growth and minimizing the thermal resistance. This shows an inverse trend with respect to thermal resistance, which in addition reinstates that 0.05 vol.% TiO_2 nanofluid is higher than 0.25 vol.% nanofluid and DI water taken into consideration in the present study.

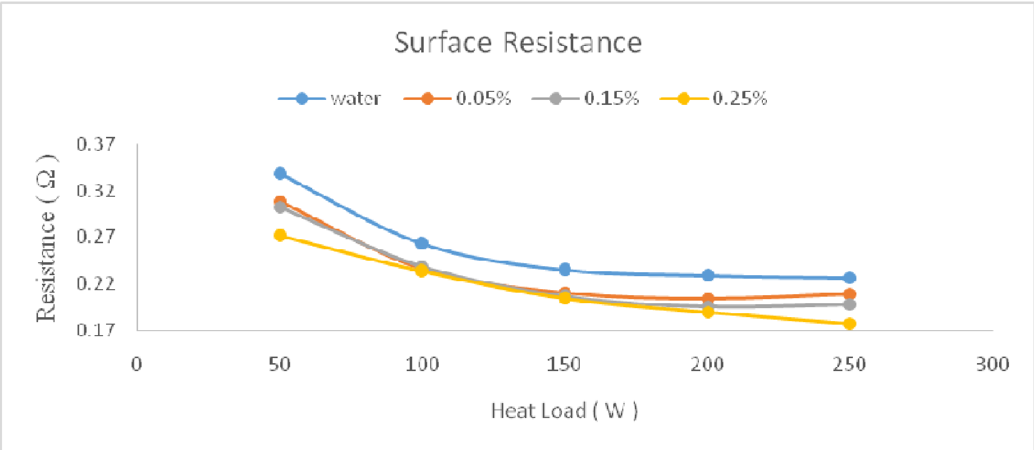

Figure 6: Surface Resistance.

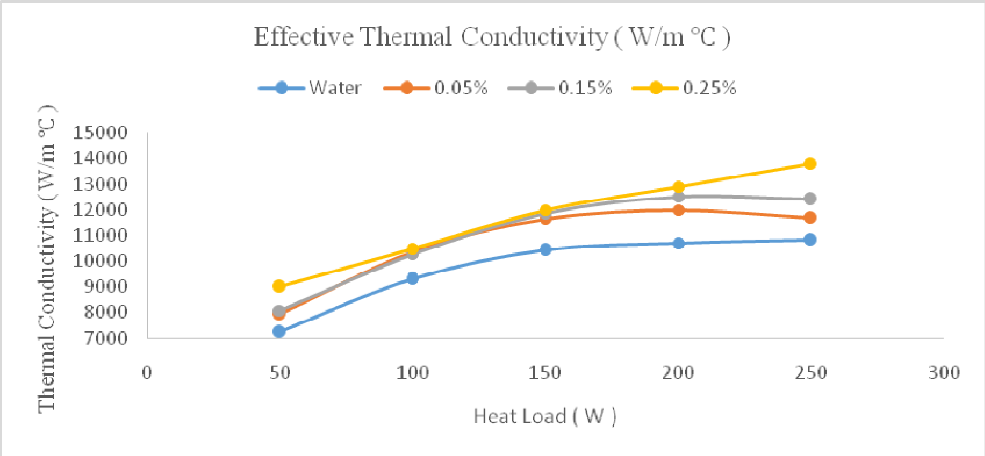

Figure 7: Effective Thermal Conductivity.

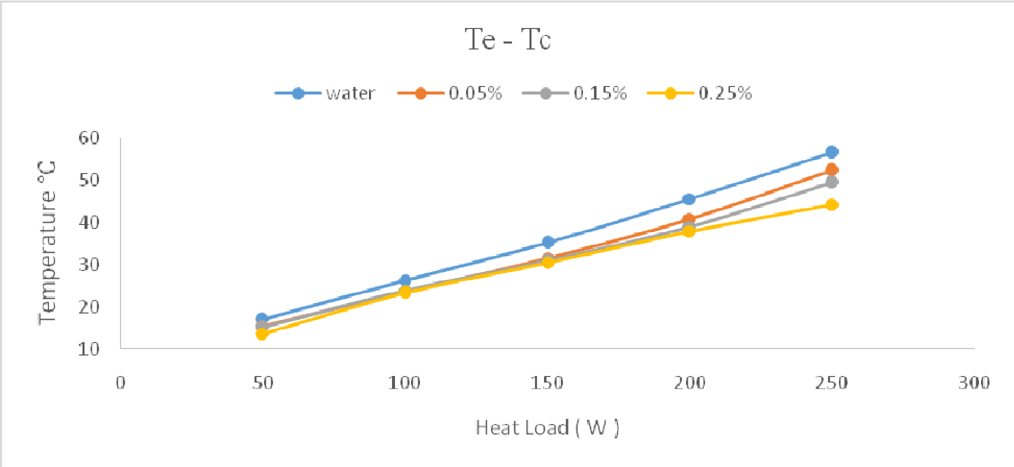

Figure 8: Temperatures Difference between Condenser and Evaporator.

From figure 7 shows the thermal conductivity and heat load. The evaporator common temperature of surface and effective thermal conductivity temperature of surface increased by way of 3.66% and 8.57% respectively, at a 50 W heat load for 0.05 vol.% TiO_2/DI water nanofluid and 7.12% and 10.95% respectively, for 0.25 vol.% TiO_2/De-Ionized water nanofluid compared toonly De-Ionized water. At 100 W heat load, the discount in temperature is 5.2 % and 10.06% for 0.05 vol.% TiO_2/DI water nanofluid and 8.12% and 11.3% for 0.25 vol.% TiO_2/DI water nanofluid. In addition a discount in temperature measuring 5.54% and 10.34% for 0.05 vol.% TiO_2/DI water nanofluid and 10.58% and a 13.07% for 0.25 vol.% TiO_2/DI water nanofluid is located at 150 W and subsequently an increase in temperature measuring 13.83% and 10.69% for 0.05 vol.% TiO_2/DI water nanofluid and 18.59% and 17.00% for 0.25 vol.% TiO_2 /DI water nanofluid is found on the most heat load, 200 W in comparison to DI water heat pipe.

From figure 8 shows that the temperature difference between condenser region and evaporator region and power. The evaporator common temperature of surface and effective temperature difference of surface dropped by way of 3.66% and 9.37% respectively, at a 50 W heat load for 0.05 vol. % DI/TiO_2 water nanofluid and 7.12% and 11.45% respectively, for 0.25 vol.% De-Ionized water/TiO_2 nanofluid compared to De-Ionized water. At 100 W heat load the discount in temperature is 5.2 % and 11.19% for 0.05 vol.% TiO_2/DI water nanofluid and 8.12% and 12.74% for 0.25 vol.% TiO_2/DI water nanofluid. In addition, a discount in temperature measuring 5.54% and 11.53% for 0.05 vol.% TiO_2/DI water

nanofluid and 10.58% and a 15.03% for 0.25 vol.% TiO_2/DI water nanofluid is located at 150 W, and subsequently an increase in temperature measuring 13.83% and 11.89% for 0.05 vol.% TiO_2/DI water nanofluid and 18.59% and 20.49% for 0.25 vol.% TiO_2 /DI water nanofluid is found on the most heat load, 200 W in comparison to DI water heat pipe.

5. CONCLUSIONS

In this experimental work, heat transfer performance of TiO_2/Deionized water nanofluid, as working liquid was experimentally analysed in a heat pipe, and results were compared with that of Deionized water heat pipe. From the results, it is evident that as increasing nanofluid concentrations (0.05 vol. %, 0.15 vol. %, 0.25 vol.%) and heat load (50 W, 100 W, 150 W, 200 W) the surface temperature increased, thermal resistance decreased and increasing the effective thermal conductivity of heat pipe.

REFERENCES

1. *Asirvatham, L. G., Nimmagadda, R., & Wongwises, S. (2013). Heat transfer performance of screen mesh wick heat pipes using silver–water nanofluid. International Journal of Heat and Mass Transfer, 60, 201–209.*
2. *Krishna, M. M., Rao, N. D. P., Prasad, B. A., & Murthy, P. V. K. (2014). Investigations on performance parameters with medium grade low heat rejection combustion chamber with rice brawn oil biodiesel. International Journal of Applied Engineering Research and Development, 4(1), 29–46.*
3. *Channapattana, S. V., Raut, S. B., Pawar, A. A., Campli, S., Sarnobat, S. S., & Dey, T. (2019). Heat Transfer Performance Analysis of Screen Mesh Wick Heat Pipe using CuO Nano Fluid. European Journal of Sustainable Development Research, 3(2), em0080.*
4. *Senthilkumar, R., Vaidyanathan, S., & Sivaraman, B. (2010). Performance analysis of heat pipe using copper nanofluid with aqueous solution of n□butanol. International Journal of Mechanical and Materials Engineering, 1(4), 251–256.*
5. *Putra, N., Septiadi, W. N., Rahman, H., & Irwansyah, R. (2012). Thermal performance of screen mesh wick heat pipes with nanofluids. Experimental thermal and fluid science, 40, 10–17.*
6. *Geete, A., & Khandwawala, A. I. (2014). Exergy analysis for 120MW thermal power plant with different inlet temperature conditions. International Journal of Research in Engineering & Technology, 2(1), 21–30.*
7. *Do, K. H., Ha, H. J., & Jang, S. P. (2010). Thermal resistance of screen mesh wick heat pipes using the water-based Al2O3 nanofluids. International Journal of Heat and Mass Transfer, 53(25-26), 5888–5894.*
8. *Lefèvre, F., Conrardy, J. B., Raynaud, M., & Bonjour, J. (2012). Experimental investigations of flat plate heat pipes with screen meshes or grooves covered with screen meshes as capillary structure. Applied Thermal Engineering, 37, 95–102.*
9. *Rymer, K., & Rachlewicz, G. Thermal Dynamics of the Permafrost active Layer in Ebba Valley (Central Spitsbergen) in the Years 2009–2012.*
10. *Shukla, K. N., Solomon, A. B., Pillai, B. C., & Ibrahim, M. (2010). Thermal performance of cylindrical heat pipe using nanofluids. Journal of Thermophysics and heat Transfer, 24(4), 796–802.*
11. *Hameed, H. G., & Rageb, A. A. (2014). Experimental investigation of thermal performance of variable conductance cylindrical heat pipe using nanofluid. International Journal of Mechanical & Mechatronics Engineering IJMME□IJENS, 14(06), 27–32.*
12. *Sonawane, P. M., Shende, M. D., & Baisane, V. P. Effect of Nanofluids on Heat Pipe Thermal Performance: A Review of the Recent Literature. International Journal of Engineering and Applied Sciences, 3(1).*

13. *Hassan, M. I., Singh, P. K., Tesfai, W., & Shatilla, Y. (2015). An experimental study of heat pipe performance using nanofluids. International journal of green energy, 12(3), 225–229.*

14. *Putra, N., Septiadi, W. N., Rahman, H., & Irwansyah, R. (2012). Thermal performance of screen mesh wick heat pipes with nanofluids. Experimental thermal and fluid science, 40, 10–17.*

15. *Kempers, R., Ewing, D., & Ching, C. Y. (2006). Effect of number of mesh layers and fluid loading on the performance of screen meshes wicked heat pipes. Applied thermal engineering, 26(5-6), 589–595.*

16. *Solomon, A. B., Ramachandran, K., & Pillai, B. C. (2012). Thermal performance of a heat pipe with nanoparticles coated wick. Applied Thermal Engineering, 36, 106–112.*

17. *Asirvatham, L. G., Nimmagadda, R., & Wongwises, S. (2013). Heat transfer performance of screen mesh wick heat pipes using silver–water nanofluid. International Journal of Heat and Mass Transfer, 60, 201–209.*

18. *Akwanya, A. N. The Interpreted World's Resistance to Perishing in Wole Soyinka's Aké.*

19. *Ghanbarpour, M., Nikkam, N., Khodabandeh, R., & Toprak, M. S. (2015). Thermal performance of inclined screen mesh heat pipes using silver nanofluids. International Communications in Heat and Mass Transfer, 67, 14–20.*

AUTHORS PROFILE

BOGGULA SHARUK received the B.Tech degree in Mechanical Engineering from the BRINDAVAN INSTITUDE OF TECHNOLOGY AND SCIENCE affiliated to Jawaharlal Nehru Technological University Anantapur, Ananthapuram, A.P, India in 2017. M.Tech in TSES from G.PULLA REDDY ENGINEERING COLLEGE (autonomous) in 2019 Research scholar in Mechanical Engineering, Kurnool, A.P. Research interested in Thermal Science and Energy System in Heat Pipe.

P. LAKSHMI REDDY received the B.Tech degree in Mechanical Engineering from the G.PULLA REDDY ENGINEERING COLLEGE (autonomous), Kurnool, A.P, India in 2002. M.Tech is completed in Energy Systems from JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR, Ananthapuram, 2005. Currently working as Asst. Professor of ME, G.Pulla Reddy Engineering College (GPREC), Kurnool, A.P. Research interested in Thermal Science and Energy System in Heat Pipe. Published in **9** International Journals.

E. SIVA REDDY received the B.Tech degree in Mechanical Engineering from the Sri Krishna University, Ananthapuram, 2003. M.Tech is completed in Energy Systems from JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR, Ananthapuram, 2006. Currently working as Asst. Professor of ME, G.Pulla Reddy Engineering College (GPREC), Kurnool, A.P. Research interested in Thermal Science and Energy System in Heat Pipe. Published in **18** International Journals.